Multivariable Impact Model of Digital Economy under the Background of Metaverse

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Abstract—This paper summarized the basic concepts and key technical components of Metaverse, explored its application and technical maturity, and by analyzing the impact of multiple variables on Metaverse digital economy, put forward a composite model of multivariable linear and coupling overlay to evaluate the level of development of digital economy, and conducted numerical calculation and analysis, which is of great significance to the study of digital economy in the context of the Metaverse. The direction and suggestions for further research are also put forward.

Keywords-metaverse; digital economy; multivariable; model

1. Introduction

As COVID-19 ravages the world and people's travel is limited, online teaching and office are starting to emerge in various parts of the world, which has led to the development of AR/VR. Moreover, the trend of immersion and virtualization of social learning office is gradually emerging. However, due to the limitations of traditional Internet online teaching and office work, together with the rapid development of science and technology in recent years, digital twins, big data, cloud computing, neural interface, 5G network and so on, it is possible to build a new digital society space [1-3]. Since 2021, the Metaverse, as a new concept, has been widely concerned by industry, finance, academia, media and the public. Facebook, the world's largest social media, changed its name to Meta, opening up a global Metaverse research and development boom and competition for technology. Many Internet giants have laid out the Metaverse, such as Microsoft, Google, Apple, NetEase, Alibaba, Tencent, TikTok and other well-known enterprises have announced their entrance into the Metaverse successively. Therefore, 2021 is also known as the first year of the Metaverse. At the present time when the world economy is in a slump, the popularity of the concept of Metaverse has brought a kind of expectation to the world: the expansion of industry, the development of digital economy and the improvement of human life [4-6].

This paper will introduce the composition and key technologies of Metaverse. Under the background of Metaverse, theoretical analysis will be carried out by establishing a multivariable impact model of the digital economy.

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2. Concepts of Metaverse Technology

2.1 Technical Composition of the Metaverse

The Metaverse combines many advanced technologies and is a mixture of technologies with different objectives. When they are combined, they point to a common goal: building a Metaverse, as shown in Fig. 1. In terms of individual technologies, for example, virtual reality technology (VR) attempts to move the real world into the virtual world, augmented reality technology (AR) attempts to put the virtual world into the real world, digital twins technology attempts to copy all the physical existence of the real world, Internet and the Internet of Things attempts to closely link people and people, people and objects, cloud computing technology attempts to integrate the various computing capabilities distributed around the world, artificial intelligence technology (AI) tries to make the machine possess the learning ability and thinking mode of human, blockchain technology tries to ensure the uniqueness and confidentiality features of social, shopping or games in the digital world, ensuring the security of digital assets, 5G technology is dedicated to timely, efficient and large-capacity information transmission [7]. The detailed connotations of several important technologies are as follows:

2.1.1 Digital Twins: Digital twins technology is a technology which combines the properties of multi-physical, multi-scale and multi-disciplinary. It has the characteristics of real-time synchronization, mapping and fidelity. Digital twins technology is used to record real-time data of objects in the real world, then copy it into the Metaverse, and display it through 3D modeling technology. Because digital twins data is real-time, the image parameters of virtual objects in the Metaverse can also truly reflect their real-world conditions.

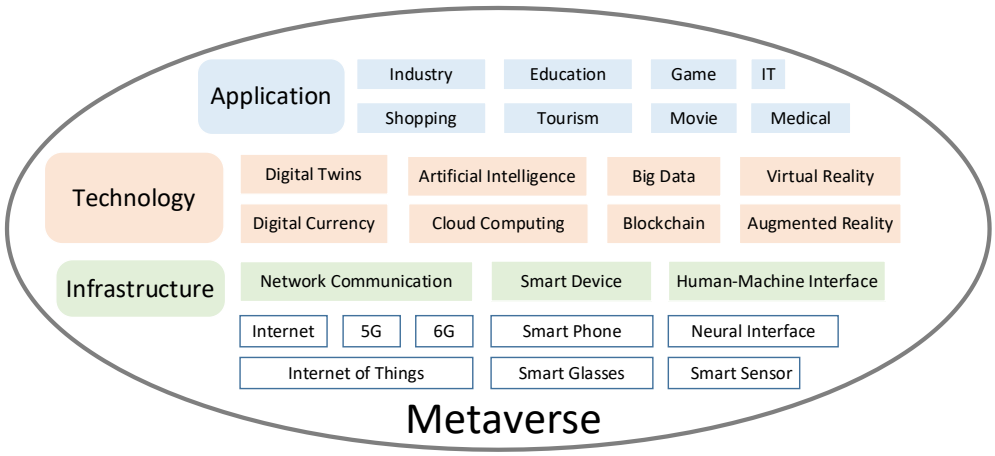

Figure 1. Composition and Application of the Metaverse.

2.1.2 **Blockchain:** Transaction also exists in the Metaverse, and the uniqueness and confidentiality of block chain technology ensure the security of digital assets. The content created by Metaverse user belongs to the user's personal digital assets. At the same time, this kind of creation greatly enriches and expands the content of the Metaverse. Blockchain technology provides security for these digital assets, greatly promotes the process of de-centralization of Metaverse creation, and makes the Metaverse economic model more open, flatter and equal.

2.1.3 **Cloud Computing:** It is a distributed computing technology that relies on server processing scattered in the network. In the Metaverse, due to the huge amount of data to be processed, there is a high demand for data computing capacity, which makes cloud computing develop well. Therefore, cloud computing is one of the very important infrastructures in the Metaverse. Cloud computing can also effectively avoid machine failures, downtime and other phenomena due to local computing.

2.2 Application of the Metaverse

Metaverse is used in a wide range of fields, such as industry, where workers can operate equipment in factory workshops in their homes through a virtual world and make more efficient decisions through artificial intelligence. According to Market Insights, the size of the global smart office market in 2025 is expected to increase by $59.6 billion from $33.3 billion in 2020. The field of education is no longer constrained by space-time conditions, allowing students to experience knowledge in real time, and also improving the imbalance of educational resources. The game field is currently the most widely used field of the Metaverse. In the field of shopping, online shopping centers are created through virtual reality, where users can browse goods, try on clothes, order purchases, etc. without the need for physical stores. In the field of tourism, people can immerse themselves in places of interest around the world, without worrying about crowded crowds and security, or even interact. In the field of movies, it can build a virtual world comparable to reality, in which the audience can have a realistic audio-visual experience, and even participate and interact. In the medical field, doctors can operate on patients around the world through virtual identities, using extended reality technology, and with the support of large data technology, making medical results more accurate.

2.3 Technical Maturity of the Metaverse

As the Metaverse is a newly developed concept, the maturity of its key technologies is inconsistent, as shown in Fig. 2, in which the highest technical maturity is 10 points, and less than 6 points are immature [8]. It can be seen that digital twins, AI and smart sensor technologies are still immature, and the development and research progress need to be accelerated. At the same time, big data and cloud computing are relatively mature because they have been developed for more than ten years, and 5G has also been commercialized, so they are also relatively mature, and have started the research on 6G.

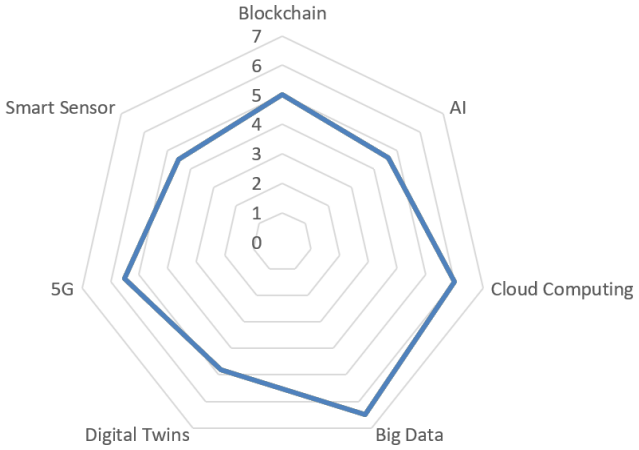

Figure 2. Technical Maturity of the Metaverse.

3. Model of the Impact on the Digital Economy

The development of digital economy under the Metaverse has been affected by many factors [9-12]. The following section analyzed the impact of different factors on the digital economy, and then proposed a mathematical model to characterize it.

Explained variable: Metaverse digital economy index, recorded as *MDE*. It is used to measure the development level of the Metaverse digital economy.

Explanatory variable:

- Technical maturity level. It is used to evaluate the maturity of the basic hardware facilities, key technologies, algorithms, etc. of the Metaverse. As a new concept, most technologies of Metaverse are relatively immature, which has a great impact on the use and promotion of the Metaverse application, user experience, and thus on the entire Metaverse digital economy. For example, in the process of the expansion of the Metaverse digital economy, the number of users and the volume of information have dramatically increased. If the maturity of cloud computing technology is not high enough, the data can not be effectively and timely processed, which will affect the direct experience of users, leading to the loss of users, reduced consumption.

- Capital input. The capital market can effectively promotes the securitization of digital assets and provides financing support for the development of the digital economy. The market continues to play a risk sharing and benefit sharing mechanism to provide long-term financial support for digital economy enterprises. Then, the enterprises can greatly improve the digital productivity of sales, manufacturing, supply chain procurement, customer management, effectively promote business quality and efficiency, and enhance differentiated competitiveness.

- Social acceptance. The emergence of new tools and technologies, whether they are accepted by the majority of social users, determines whether they can be effectively promoted. Particularly obvious is that with the arrival of the post epidemic era, a large number of offline daily production has gradually shifted to online, such as the government affairs platform, where

many things can be handled online, saving time and economic costs. The digital economy has brought people a lot of new feelings, enabling many previously unimaginable scenarios to be realized. The higher the social acceptance of digital economy, the more it can promote its development.

- Policy support. Policy support can accelerate the development of digital economy in many ways. Countries are racing to formulate digital economy development strategies and introduce incentive policies. For example, China has upgraded it to a national strategy, implemented the strategy of network power and the national big data strategy, expanded the space of the network economy, promoted the integrated development of the Internet and the economy and society, and supported various Internet based innovations.

- Industry impact. Digital economy has infiltrated into the production activities of most industries. However, the combination of various industries and digital economy has different development potentials. First, the combination of secondary industry and digital economy mainly depends on the cultivation, development and simple processing and utilization of natural raw materials. The combination of tertiary industry departments and digital economy mainly focuses on service industry and entertainment industry. The influence of different industries will also promote the development of digital economy to a different extent.

The contributions of all parameters are summarized and linearly weighted to obtain the linear comprehensive evaluation results reflecting the Metaverse digital economic level MDE_{linear}, which is calculated by equation (1):

$$MDE_{linear}=\beta_0+\beta_1 matu+\beta_2 cap+\beta_3 acc+\beta_4 pol+\beta_5 ind \quad (1)$$

Where, the coefficients β_1, β_2, β_3, β_4, β_5 represent the linear impact of technology maturity (*matu*), capital input (*cap*), social acceptance (*cacc*), policy support (*pol*) and industry impact (*ind*) on the digital economy respectively.

At the same time, the above multi parameters are also highly coupled with each other. For example, the social acceptance is affected by the technical maturity level. Only when the technology is mature enough can it be accepted and used by users. And the technology maturity is also affected by the capital input and policy support. Only when the capital investment and policy support are sufficient can the technology get breakthrough development. Moreover, capital input is affected by industry impact, and investment funds often flow into key industries or industries with rich profits. The following Table 1 shows the coupling relationship between the parameters. The influence coefficient between parameters is set here through expert experience. 0 indicates a small relationship between parameters, 1 indicates a direct relationship, and 0.5 indicates a weak relationship.

Table 1 Coupling Relationship

Original Variables	**Affected Parameter Variables**				
	matu	***cap***	***acc***	***pol***	***ind***
matu	0	0.5	1	0.5	0
cap	1	0	0	0	0
acc	0	0.5	0	0.5	0.5

pol	0	0.5	0	0	0.5
ind	0	1	0	0.5	0

Table 1 can be expressed as matrix, $\boldsymbol{A}=(\alpha_{ij})_{m\times n}$. Where, α_{ij} represents the influence factor of row i on column j, m and n are both 5. Then, the following formula can be obtained:

$$\boldsymbol{P}=[matu\ cap\ acc\ pol\ ind] \tag{2}$$

$$MDE_{coupled}=\boldsymbol{P}\times|\boldsymbol{A}^{-1}|\boldsymbol{A}\times\boldsymbol{P}^{\mathrm{T}} \tag{3}$$

$$MDE=MDE_{linear}+MDE_{coupled} \tag{4}$$

Where, $\boldsymbol{P}$ is the variable vector, $\boldsymbol{A}$ is the coupling relationship matrix between multiple variables, $MDE_{coupled}$ is the mutual contributions between multiple variables to the digital economy, and the total amount of the digital economy MDE is the sum of MDE_{linear} and $MDE_{coupled}$.

4. Numerical Analysis

In order to numerically calculate and analyze the above mathematical model, assuming that the linear contribution between multiple variables is 1, i.e. each of β_i are 1, considering each year the different variables increase linearly from 1 to 20. With formulas (1) to (4), the numerical calculation results are shown in Fig. 3.

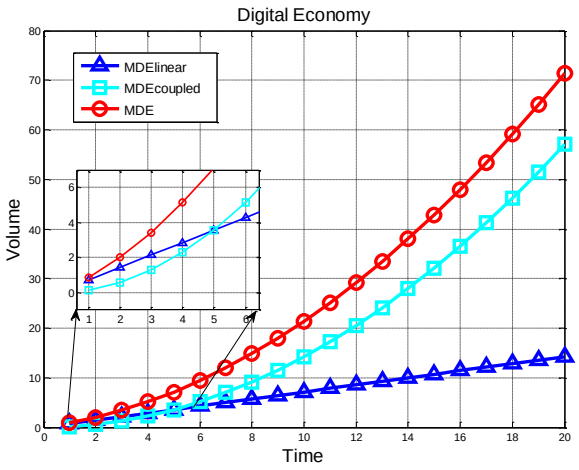

Figure 3. Numerical Results of the Metaverse Digital Economy.

It can be seen that in the early stage of digital economy development, linear growth plays a major role. As development continues, the coupling relationship of different variables plays a mutually promoting role, which makes $MDE_{coupled}$ to approximate exponential growth. Finally, when the digital economy is developed, it is impossible for each variable to exist independently, because the entire Metaverse digital economy has become a complex of multivariable interaction and mutual development.

5. Conclusion

This paper summarized the essential concepts and key technical components of the Metaverse, explored its application and technical maturity, and put forward a multiple linear regression model to evaluate the level of digital economic development by analyzing the influence of various factors on the Metaverse digital economy, provided a new idea for the study of the digital economy in the background of the Metaverse.

In the future, it is necessary to carry out follow-up research according to the following points:

1) On the basis of the above mathematical model, further empirical analysis is needed to explore the weight coefficients of the five factors and determine the contribution of different factors to the digital economy.

2) The range of variables needs to be further optimized, and different elements in technology, application and infrastructure are also used as explanatory variables to improve the prediction range and accuracy of the mathematical model.

3) It is necessary to carry out digital economy analysis for different industries in the application list, and propose specific measures to promote the development of industry digital economy.

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References

[1] S. -M. Park and Y. -G. Kim, "A Metaverse: Taxonomy, Components, Applications, and Open Challenges," in IEEE Access, vol. 10, pp. 4209-4251, 2022.

[2] D. Van Huynh, S. R. Khosravirad, A. Masaracchia, "Edge Intelligence-Based Ultra-Reliable and Low-Latency Communications for Digital Twin-Enabled Metaverse," in IEEE Wireless Communications Letters, vol. 11, no. 8, pp. 1733-1737, Aug. 2022.

[3] M. Qu, Y. Sun and Y. Feng, "Digital Media and VR Art Creation for Metaverse," 2022 2nd Asia Conference on Information Engineering (ACIE), 2022, pp. 48-51.

[4] J. N. Njoku, C. Ifeanyi Nwakanma and D. -S. Kim, "The Role of 5G Wireless Communication System in the Metaverse," 2022 27th Asia Pacific Conference on Communications (APCC), 2022, pp. 290-294.

[5] K. Lippert, M. N. R. Khan, M. M. Rabbi, A. Dutta and R. Cloutier, "A Framework of Metaverse for Systems Engineering," 2021 IEEE International Conference on Signal Processing, Information, Communication & Systems (SPICSCON), 2021, pp. 50-54.

[6] M. U. Ananya Babu and P. Mohan, "Impact of the Metaverse on the Digital Future: People's Perspective," 2022 7th International Conference on Communication and Electronics Systems (ICCES), 2022, pp. 1576-1581.

[7] M. Pigultong, "Cognitive Impacts of Using a Metaverse embedded on Learning Management System for Students with Unequal Access to Learning Resources," 2022 10th International Conference on Information and Education Technology (ICIET), 2022, pp. 27-31.

[8] D. Wang, X. Yan and Y. Zhou, "Research on Metaverse: Concept, development and standard system," 2021 2nd International Conference on Electronics, Communications and Information Technology (CECIT), 2021, pp. 983-991.
[9] C. Chen et al., "When Digital Economy Meets Web3.0: Applications and Challenges," in IEEE Open Journal of the Computer Society, vol. 3, pp. 233-245, 2022.
[10] T. V. Ershova, Y. E. Hohlov and S. B. Shaposhnik, "Methodology for Digital Economy Development Assessment as a Tool for Managing the Digital Transformation Processes," 2018 Eleventh International Conference "Management of large-scale system development" (MLSD, 2018, pp. 1-3.
[11] D. Vorobieva, I. Kefeli, M. Kolbanev and A. Shamin, "Architecture of Digital Economy," 2018 10th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), 2018, pp. 1-7.
[12] C. L. Pan, Y. Yu, W. Zhou, W. Zheng, C. Ou and H. Xu, "Research on Digitizing and E-commerce in the Era of the Digital Economy," 2021 2nd International Conference on E-Commerce and Internet Technology (ECIT), 2021, pp. 189-192.